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Stormwater Management Plan Review Course

Virginia Department of Environmental Quality

Module 9

Evaluating Water Quantity Compliance

Virginia Department of Environmental Quality

Module 9. Content

9a. Effective CNs *(review)*

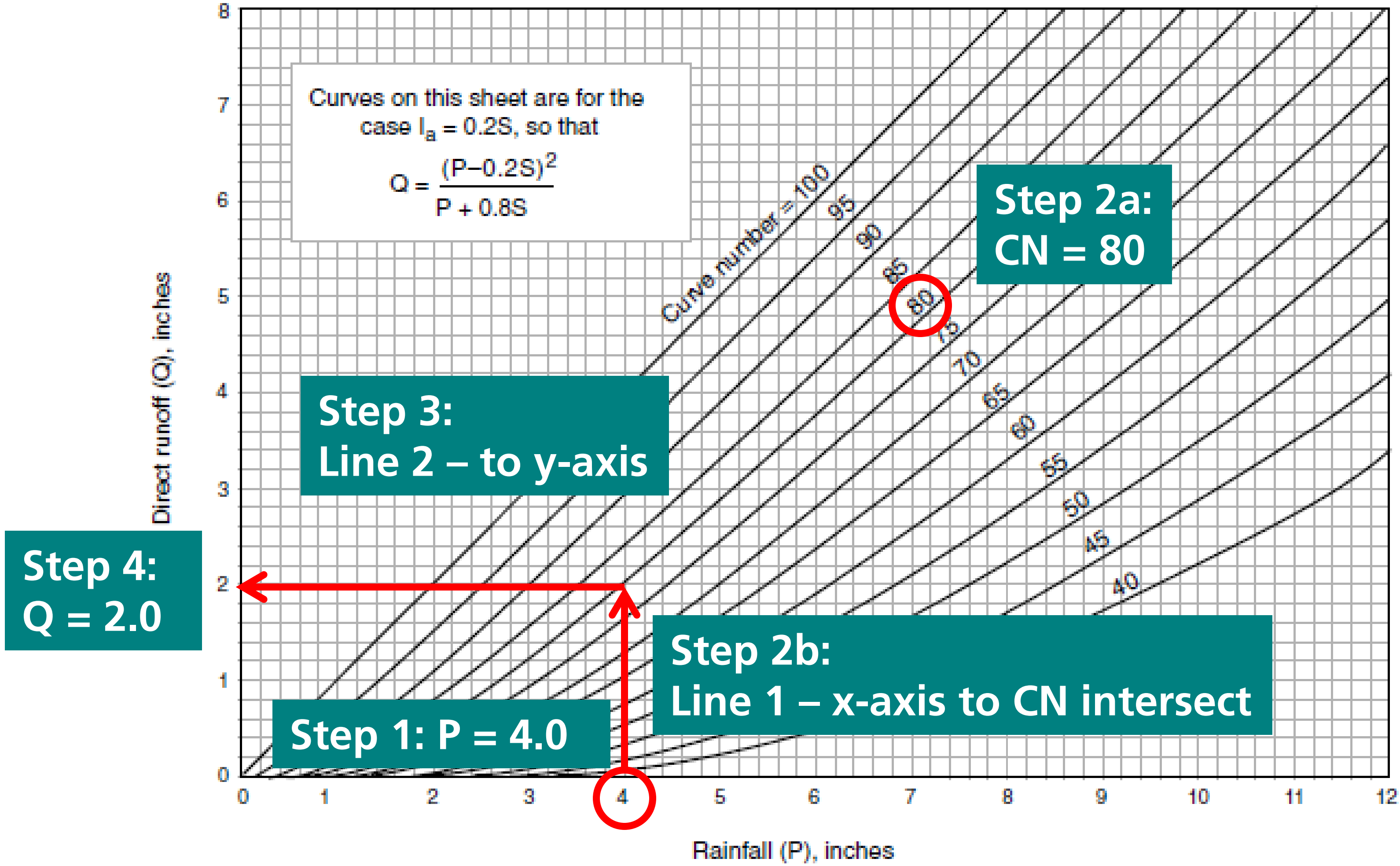
9b. Routing vs. CN Adjustment

9c. Enhancing Storage at Practices

9d. Traditional CNs

9e. Rational Method *(review)*

Review – *Graphical Solution*



Given a watershed with a CN of 80, what would be the direct runoff (Q) from a rainfall (P) of 4.0 inches?

Review – *Tabular Solution*

PG 3

Table 2-1 Runoff depth for selected CN's and rainfall amounts [1/]

Rainfall	40	45	50	55	60	65	70	75	80	85	90	95	98
	Runoff depth for curve number of—												
	inches												
1.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.08	0.17	0.32	0.56	0.79
1.2	.00	.00	.00	.00	.00	.00	.03	.07	.15	.27	.46	.74	.99
1.4	.00	.00	.00	.00	.00	.02	.06	.13	.24	.39	.61	.92	1.18
1.6	.00	.00	.00	.00	.01	.05	.11	.20	.34	.52	.76	1.11	1.38
1.8	.00	.00	.00	.00	.03	.09	.17	.29	.44	.65	.93	1.29	1.58
[illegible]	[illegible]	[illegible]	.00	.02	.06	.14	.24	.38	.56	.80	1.09	1.48	1.77
[illegible]	[illegible]	[illegible]	.02	.08	.17	.30	[illegible]	[illegible]	.89	1.18	1.53	1.96	2.27
3.0	.00	.02	.09	.19	.33	.51	[illegible]	[illegible]	1.25	1.59	1.98	2.45	2.77
3.5	.02	.08	.20	.35	.53	.75	[illegible]	[illegible]	1.64	2.02	2.45	2.94	3.27
4.0	.06	.18	.33	.53	.76	1.03	1.33	1.67	2.04	2.46	2.92	3.43	3.77
4.5	.14	.30	.50	.74	1.02	1.33	1.67	2.05	2.46	2.91	3.40	3.92	4.26
5.0	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	4.42	4.76

Step 1: P = 4.0

Step 2: CN = 80

Step 3: Q = 2.04

Given a watershed with a CN of 80, what would be the direct runoff (Q) from a rainfall (P) of 4.0 inches?

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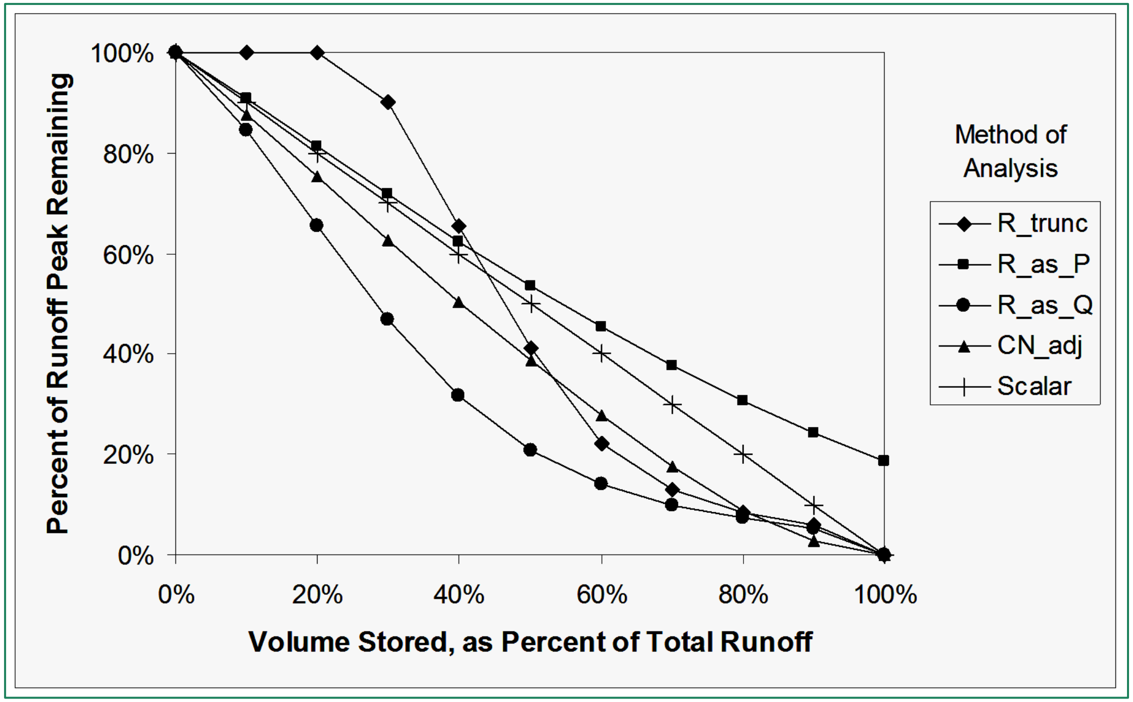
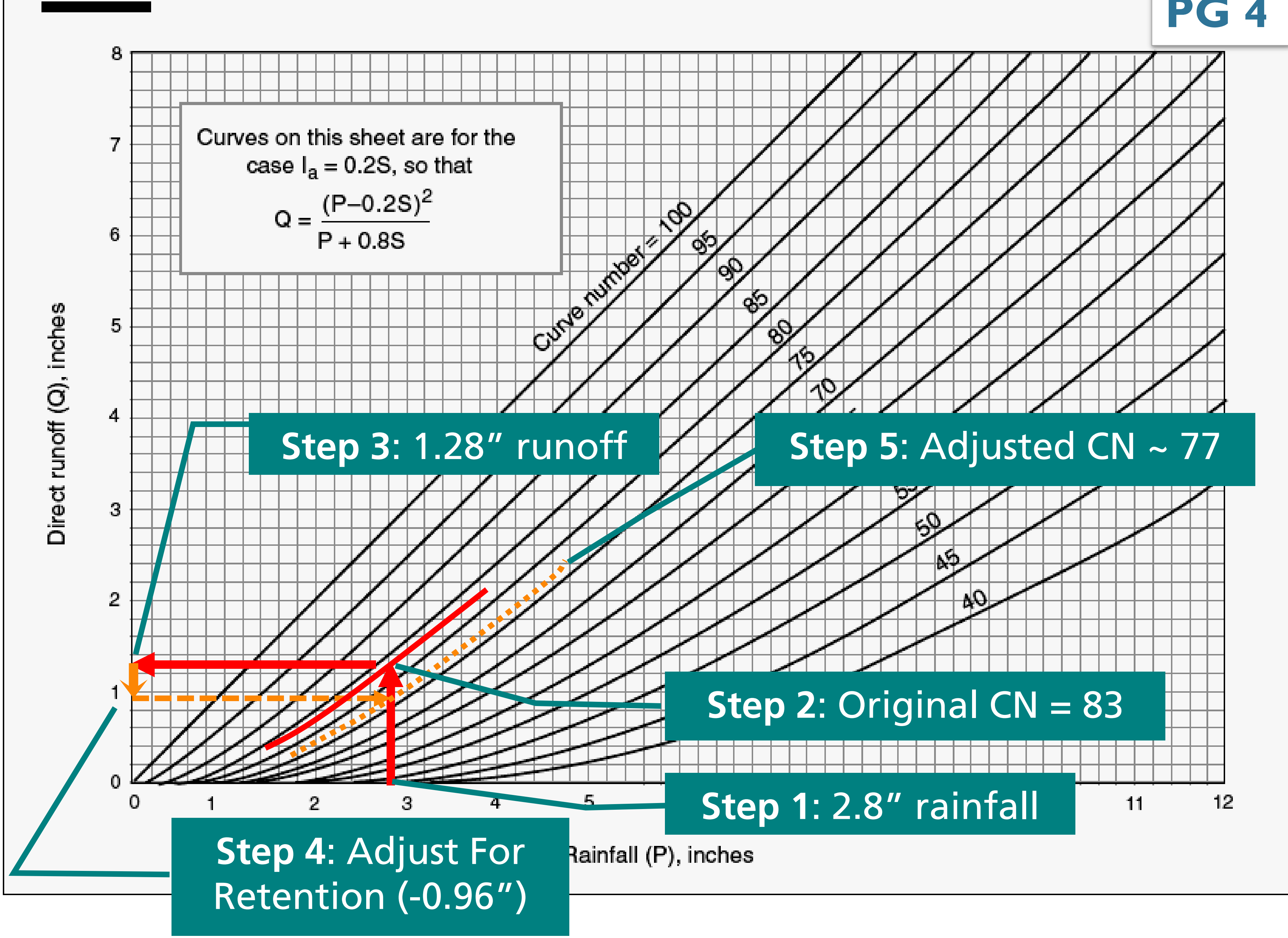
Why are CN Adjustments Useful?

- Simplified view of small storage amounts distributed on landscape
- Minimize complex modeling



Excerpted from work by Paul R. Koch, Ph.D., P.E.

Figure 2-1 Solution of runoff equation.



How Does the Spreadsheet Determine (retention) Storage?

Residual volume from upstream BMP contributes to next BMP in treatment train for sizing

Practice	on of Credit	Credit	Credit Area (acres)	Volume from Upstream RR Practice (cf)	Runoff Reduction (cf)	Remaining Runoff Volume (cf)	Phosphorus Efficiency (%)	Phosphorus Load from Upstream RR Practices (lbs)	Untreated Phosphorus Load to Practice (lbs.)	Phosphorus Removed By Practice (lbs.)	Remaining Phosphorus Load (lbs.)	Downstream Treatment to be Employed
7.a. Infiltration #1 (Spec #8)	olume reduction	0.50	0.00	0	0	0	25	0.00	0.00	0.00	0.00	
7.b. Infiltration #2 (Spec #8)	olume reduction	0.90	1.00	0	3104	345	25	0.00	2.16	2.00	0.16	8.b. ED #2
	olume reduction	0.90	1.00	0	719	80	25	0.00	0.50	0.46	0.04	8.b. ED #2
8. Extended Detention Pond												
8.a. ED #1 (Spec #15)	lume reduction	0.00	0.00	0		0					.00	
	lume reduction	0.00	0.00	0		0	15				.00	
8.b. ED #2 (Spec #15)	olume reduction	0.15	1.00	345	569	3224	15				.68	
	olume reduction	0.15	0.00	80	12	68	15	0.04	0.00	0.01	0.03	

Runoff Reduction Volume

What Does that Volume Mean?

- That volume is the estimated fraction of the runoff (annually) that is reduced
- Multiplied by a 1-inch rainfall

Practice	on of Credit	Credit	Credit Area (acres)	Volume from Upstream RR Practice (cf)	Runoff Reduction (cf)	Remaining Runoff Volume (cf)	Phosphorus Efficiency (%)	Phosphorus Load from Upstream RR Practices (lbs)	Untreated Phosphorus Load to Practice (lbs.)	Phosphorus Removed By Practice (lbs.)	Remaining Phosphorus Load (lbs.)	Downstream Treatment to be Employed
7.a. Infiltration #1 (Spec #8)	lume reduction	0.50	0.00	0	0	0	25	0.00	0.00	0.00	0.00	
7.b. Infiltration #2 (Spec #8)	lume reduction	0.90	1.00	0	3104	345	25	0.00	2.16	2.00	0.16	8.b. ED #2
	lume reduction	0.90	1.00	0	719	80	25	0.00	0.50	0.46	0.04	8.b. ED #2
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8.b. ED #2 (Spec #15)	lume reduction	0.15	1.00	345	569	3224	15				.68	
	lume reduction	0.15	0.00	80	12	68	15	0.04	0.00	0.01	0.03	

Runoff Reduction Volume

What are the limitations?

- *Storage-based* practices
  - Volume often much smaller than actual storage provided
  - Designers may also customize storage characteristics to reduce flows

    (more than spreadsheet can account)

Bioretention Level 1 - Example

- Given:
  - Level 1 bioretention
  - B type soils
  - 2 Acre DA (50% Imp, 50% Turf)
- Sizing:
  - Tv = volume
  - Surface area is 1 Tv divided by storage depth
  - Storage depth ~ 1.4 ft. (typical)

Bioretention Level 1 - Example

- Size:
  - Tv = 4175 c.f.
  - SA = 4175/1.4 = 2982 s.f.

6. Bioretention								
6.a. Bioretention #1 or Urban Bioretention (Spec #9)	impervious acres draining to bioretention	40% runoff volume reduction	0.40	1.00	0	1379	2069	25
	turf acres draining to bioretention	40% runoff volume reduction	0.40	1.00	0	290	436	25

- RR "Credit" = 1379 + 290 = 1669 c.f.
  - 40% of volume draining to facility

	1-year storm	2-year storm	10-year storm
Target Rainfall Event (in)	2.60	3.60	4.60

Drainage Area A	
Drainage Area (acres)	2.00
Runoff Reduction Volume (cf)	1,670

Drainage Area B	
Drainage Area (acres)	0.00
Runoff Reduction Volume (cf)	0

Drainage Area C	
Drainage Area (acres)	0.00
Runoff Reduction Volume (cf)	0

Drainage Area D	
Drainage Area (acres)	0.00
Runoff Reduction Volume (cf)	0

Drainage Area E	
Drainage Area (acres)	0.00
Runoff Reduction Volume (cf)	0

Based on the use of Runoff Reduction practices in the selected drainage areas, the spreadsheet calculates an adjusted $RV_{Developed}$ and adjusted Curve Number.

Drainage Area A		A soils	B Soils	C Soils	D Soils
Forest/Open Space -- undisturbed, protected forest/open space or reforested land	Area (acres)	0.00	0.00	0.00	0.00
	CN	30	55	70	77
Managed Turf -- disturbed, graded for yards or other turf to be mowed/managed	Area (acres)	0.00	1.00	0.00	0.00
	CN	39	61	74	80
Impervious Cover	Area (acres)	0.00	1.00	0.00	0.00
	CN	98	98	98	98

Weighted CN	S
80	2.50

	1-year storm	2-year storm	10-year storm
$RV_{Developed}$ (in) with no Runoff Reduction	0.96	1.72	2.55
$RV_{Developed}$ (in) with Runoff Reduction	0.73	1.49	2.32
Adjusted CN	75	77	77

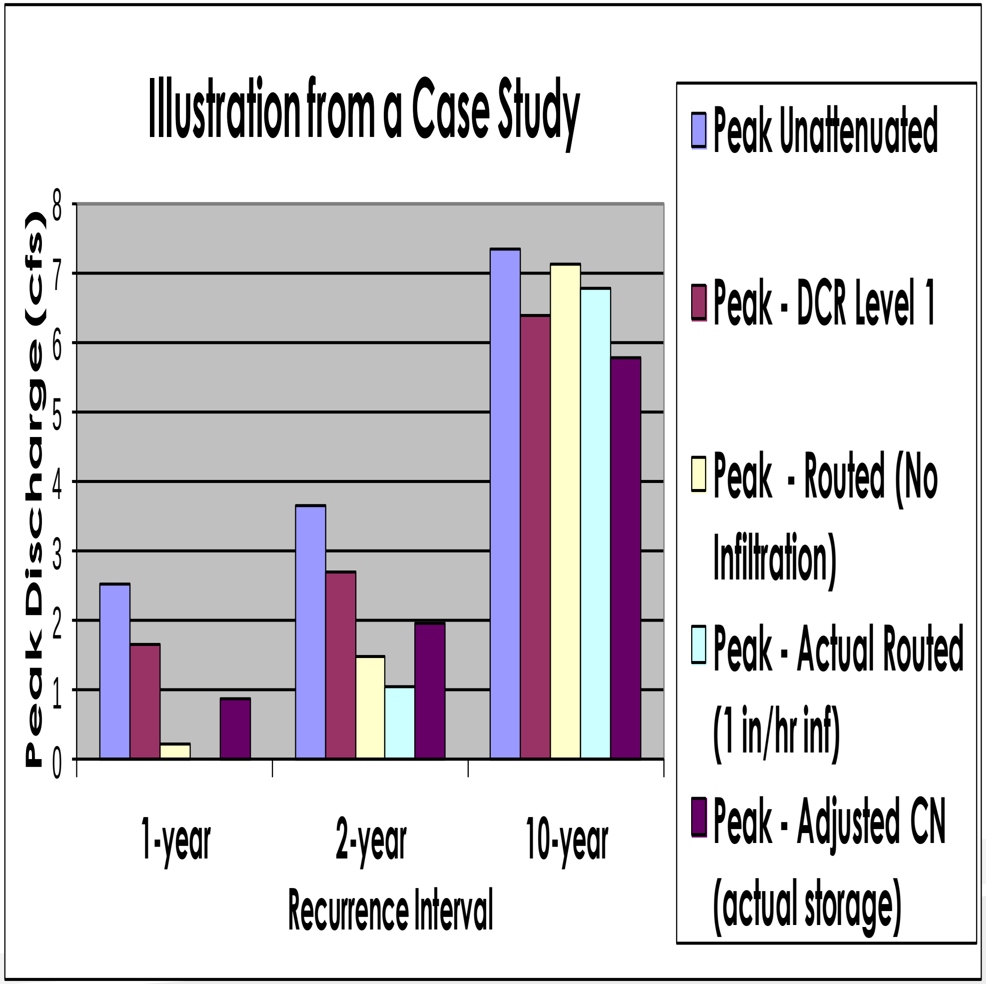
Interim Summary

- Practice is calculated to reduce:
  - 1 year storm volume
    - from: 0.96 in
    - to: 0.73 in
  - For the 2 acre catchment
    - 0.96 x 2 x 43560/12 = 6970 c.f.
    - 0.72 x 2 x 43560/12 = 5227 c.f.
- Given total runoff 1-yr = 6,970 c.f.
- Actual storage greater than 4,175 c.f.
- Credit is only 1,669 c.f.

So what does this mean?

- Routed storage-based practices can generate **much lower discharges than CN adjustment**
- Expect designers to route practices
- CN Adjustment **AND** Routing for given practice not allowed…..

ALWAYS discount the routed practice from CN adjustments)



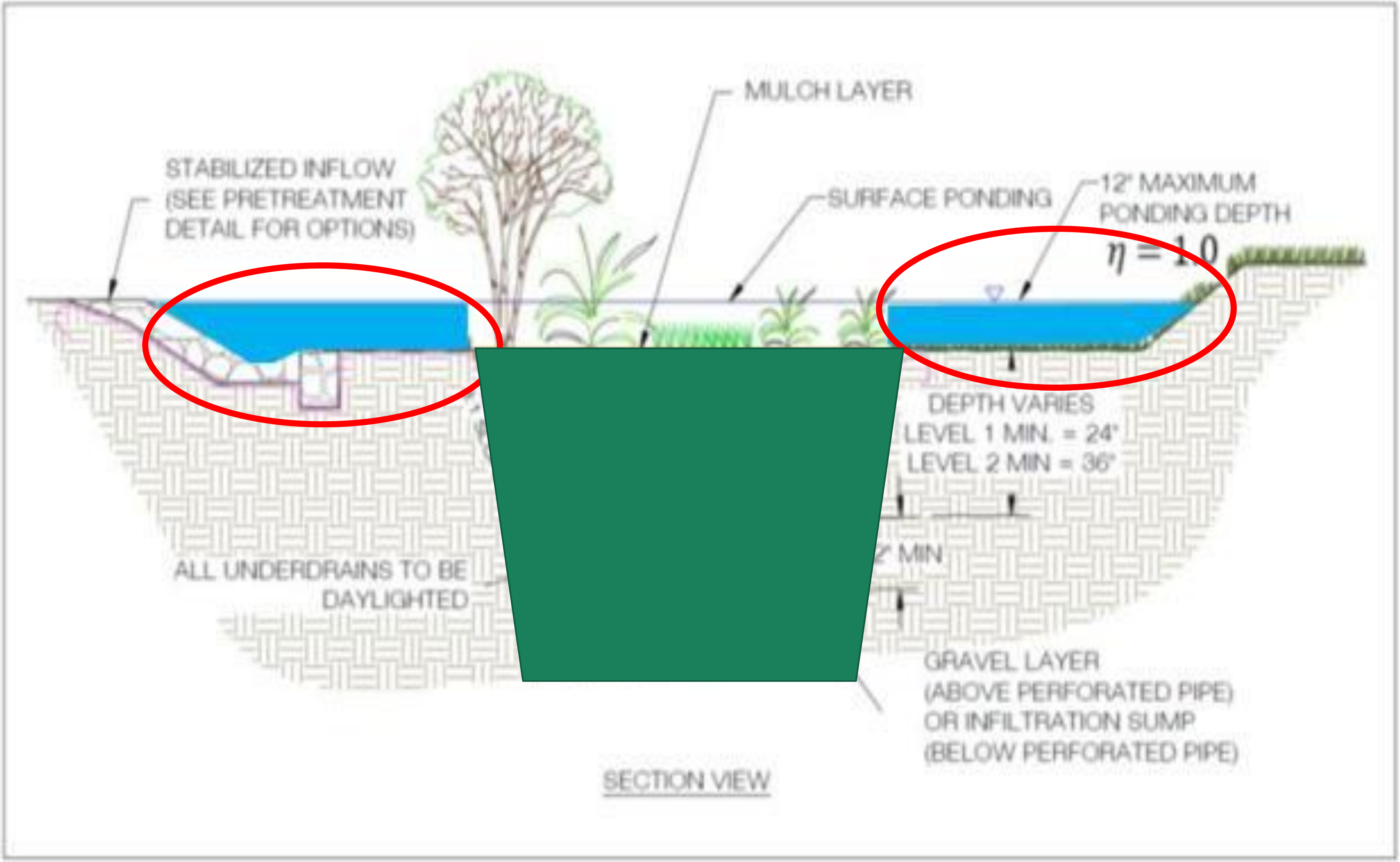
Storage Optimization

- Storage can be customized to reduce discharges for water quantity design
- Examples for bioretention customization include:
  - Increasing media thickness
  - Increasing sump depth
  - Increasing ancillary surface storage

Bioretention

VIRGINIA DEQ STORMWATER DESIGN SPECIFICATION No. 9

Optimization and Storage:



Curve Numbers (Spreadsheet vs Lookup Table)

- May see differences between spreadsheet CNs vs TR-55 CN Tables
- Either acceptable in designs
- Designers may use spreadsheet CNs
- Understand which CN you are dealing with and why

Table 2-2a Runoff curve numbers for urban areas [1/]

Cover description: Cover type and hydrologic condition	Average percent impervious area [2/]	Curve numbers for hydrologic soil group: A	B	C	D
Fully developed urban areas (vegetation established)					
Open space (lawns, parks, golf courses, cemeteries, etc.)[3/]:					
Poor condition (grass cover < 50%)		68	79	86	89
Fair condition (grass cover 50% to 75%)		49	69	79	84
Good condition (grass cover > 75%)		39	61	74	80
Impervious areas:					
Paved parking lots, roofs, driveways, etc. (excluding right-of-way)		98	98	98	98
Streets and roads:					
Paved; curbs and storm sewers (excluding right-of-way)		98	98	98	98
Paved; open ditches (including right-of-way)		83	89	92	93
Gravel (including right-of-way)		76	85	89	91
Dirt (including right-of-way)		72	82	87	89
Western desert urban areas:					
Natural desert landscaping (pervious areas only) [4/]		63	77	85	88
Artificial desert landscaping (impervious weed barrier, desert shrub with 1- to 2-inch sand or gravel mulch and basin borders)		96	96	96	96
Urban districts:					
Commercial and business	85	89	92	94	95
Industrial	72	81	88	91	93
Residential districts by average lot size:					
1/8 acre or less (town houses)	65	77	85	90	92
1/4 acre	38	61	75	83	87
1/3 acre	30	57	72	81	86
1/2 acre	25	54	70	80	85
1 acre	20	51	68	79	84
2 acres	12	46	65	77	82
Developing urban areas					
Newly graded areas (pervious areas only, no vegetation) [5/]		77	86	91	94

Rational and Modified Rational Method

- Drainage areas ≤ 200 acres
  - VSMP authority can allow Rational Method for evaluating peak discharges
  - VSMP authority can allow Modified Rational Method for evaluating volumetric flows to stormwater conveyances

Rational and Modified Rational Method (continued)

- Drainage infrastructure sizing
- Sheet flow analysis
- How do you show SWM compliance?
  - No volume with Rational
  - No 24-hr hydrograph in Rational and Modified Rational

Questions?